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LED Array Development: Highlights and Challenges of Red Light Therapy

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Abstract

Red light therapy (RLT) is a recent development that faces much uncertainty due to its novel nature. In essence, it has been found that the light photons trigger respiratory chain components which in turn activate a signaling cascade, and thus result in a cellular response. Some of these biological reactions aid in healing, skin repair, inflammation reduction, and functional improvement. Although such knowledge has been retained, scientists still struggle to understand how RLT truly works and the risks that are paired along. Though limited research has been conducted, this form of therapy allows for a wide variety of applications due to the numerous dosimetry parameters. As parameters have countless combinations, RLT can be used for people of varying ages, skin conditions, illnesses, and health backgrounds. Though seeming positive, such wide combinations leave room for the unpredictability of specific settings that pertain to each user. An additional concern is a basic accessibility; RLT has yet to be integrated into mainstream health improvement. In all, RLT provides optimistic solutions for high-performing humans, though much more research is required to uncover all the risks.

Keywords: Red light therapy, Photons, Skin treatment, Therapy, Healing, Inflammation, Health

1. Introduction

Recent scientific developments like Red Light Therapy (RLT) have increased the general well-being of high-performing people such as athletes and trainers. This form of physical therapy has been discovered to "treat a multitude of conditions that require stimulation of healing, relief of pain and inflammation, and restoration of function" (Avici et al., 2013). Despite these many benefits, however, controversy flows around the topic due to the uncertainty "about fundamental molecular and cellular mechanisms responsible for transducing signals from the photons" (Avici et al. 2013) as well as the "significant variations in terms of dosimetry parameters" (Avici et al., 2013) needed for phototherapy. Since this type of phototherapy has yet to be accepted into the mainstream world of, "science and medicine" (Sontea et al., 2013), there is less access. Although these issues prevail, the idea of red light therapy is simple. Pagán (2021) from WebMD simply explains it as how the mitochondria, "soaks up [energy] from red light".

The history of RLT dates back to the late 19th century by a Danish physician named Niels Finsen, who developed RLT in 1896 as a treatment for lupus vulgaris, a type of tuberculosis (Vorwaller, 2020). Vorwaller (2020) reports Dr. Finsen's historical process as using electric light a total of 15 times, each time focused on the same 2cm of skin. Finding

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immense success, Dr. Finsen was awarded the Nobel Prize of Medicine following this utilization (Lightwave, n.d.) in 1903. Light therapy research ramped up in the 1960s in Eastern Europe to heal "chronic pain, arthritis and associated conditions, joint rehabilitation, and soft-tissue injury along with other medical ailments" (Lightwave, n.d.). After word spread about the success and effectiveness of RLT, it is not surprising that this method became a popular skin treatment "given the claims that it did not damage your skin surface and had many benefits that promoted skin health," (Team Nutrisense, 2022).

While the pandemic has unfolded prevailing health issues for citizens of the world, considering new technological development like RLT is essential in aiding the evolving human body. For instance, there have been claims that this form of therapy will aid in curing severe illnesses such as the Niemann-Pick disease purely due to the properties of light (Schwarcz 2022). RLT is a convenient, effective, low-cost, and low-risk solution for populations such as high-performing athletes and seniors. For instance, seniors may experience skin problems, typically brought with old age; RLT can provide a simple solution to energy rejuvenation and wound repair. All in all, "RLT is generally safe and may be a very effective treatment option for people seeking smaller changes in their skin or to keep the skin healthy and reduce inflammation" (Medical News Today, 2019). This paper will explore more about RLT and the effect of LED array development on the advantages and risks. As with any development, scientists currently battle out the pros and cons of RLT and its applications in hopes to build technology that advances humanity.

2. Internal Action

While the results of RLT can be significant, it is critical to understand how this form of phototherapy works. Victor Sontea (2013) and his colleagues explored the mechanism of RLT in their 2013 E-Health and Bioengineering Conference. Sontea et al. (2013) explain how the photo-bio-modulation, a form of light therapy that utilizes non-ionizing light sources (Light Force Therapy Lasers), by red light, "has been ascribed to the activation of mitochondrial respiratory chain components resulting in [the] initiation of a signaling cascade that promotes cellular proliferation and cytoprotection" (Sontea et al., 2013). In short, this means that the photons from the red light trigger a cellular response in the cells, leading to the advantages of RLT. On the contrary, discussions around the uncertainty of how the cascading signals actually work have been a topic of controversy. Presently, signaling cascades are a topic of scientific interest where researchers are working to confirm the directions and effects of each cascade in a definite manner (Catozzi et al., 2016). Nonetheless, studies have shown that "proposed underlying mechanisms include the photostimulation of terminal molecules in the electron transport chain and the subsequent adenosine triphosphate (ATP) concentration increase" (Wunsch et al., 2014). Likewise, low-level laser light therapy, which includes RLT, activates, "electron transport, ATP nitric oxide release, blood flow, reactive oxygen species increase and diverse signaling pathways" (Avici et al., 2013). As a result of higher ATP production, biological systems can work much more efficiently, leading to the numerous advantages of RLT.

Overall, in order for RLT benefits to be present, the light must initiate a chain reaction that prompts other organs within one's body, resulting in the highlights of RLT that are discussed later on in this paper. By calling on molecules that eventually go through cellular respiration, energy production is generated at a higher level. Notably, the human body carries energy through ATP, which is then used for processes such as muscle contraction, metabolism, growth, and repair (Dunn & Grider, 2022).

3. Conditional Improvement

After comprehending the RLT effects on our body, we can now dive into the physical improvements that this form of phototherapy creates. As LED developments are constantly evolving, benefits such as "lower cost,…absence of heat, and [large] arrays for large wound treatment," (Sontea et al., 2013) have been found. Although scientists believe that blue light is just as effective as red light, Sontea et al. (2013) argue that "light close to and in

the red and infrared range effectively promotes wound healing". Likewise, Avici et al. (2013) explain how "red light is known to penetrate deeper in tissues when compared to blue light". As suggested by both papers, red light seems to be more effective in healing in comparison to blue light. Important to note, however, is that combining both blue and red light can produce an "overall decrease melanin level" (Avici et al., 2013, p.10), which produces depigmentation and can increase one's risk of sunburns. Nevertheless, the regenerative capabilities of red light on its own have other advantages, including dental pain reduction, hair loss improvement, and tendonitis recovery (Pagán, 2021). With the introduction of LED devices, these treatments are much easier to apply as the devices have, "simplified the application to large areas of skin" (Avici et al., 2013, p.12).

A study by Wunsch & Matuschka (2014) explored the RLT application on 136 volunteers and it was noted that there was a significant experience in improvement of personal assessments of, "skin feeling and complexion in clinical outcomes as assessed by collagen density and skin roughness measurements and in the reduction of fine lines and wrinkles. Wunsch & Matuschka (2014) explain their method by saying the following: "113 subjects randomly assigned into four treatment groups were treated twice a week with either 611–650 or 570–850 nm polychromatic light (normalized to ~9 J/cm2 in the range of 611–650 nm) and were compared with controls (n=23)". Moreover, 30 sessions were implemented for each subject with appropriate evaluation. This study evidently shows that RLT provides a safe, "atraumatic photobiomodulation treatment of skin tissue with high satisfaction rates" (Wunsch & Matuschka, 2014). Clearly, light-emitting diodes (LEDs) are effective light sources that have advantages such as broad beam width, and the "expected signal strength given the direction and radiation distance of an antenna" (A. H. Systems) and cost efficiency (Rohringer et al., 2017).

Overall, such sources emphasize the benefits that come with RLT, both in an efficient and reliable manner. Though researchers clearly believe in this solution, there seems to be a concern surrounding the temporary-like expectation that RLT creates. As parameters of RLT (further discussed in the following section) create countless combinations, one must wonder how a patient can confirm the appropriate number of RLT sessions, before a burn occurs.

4. Complications and Accessibility

With any new developments, there are also risks, and RLT is no different. With limited time and knowledge of the novel solution, this form of phototherapy comes with numerous complications. Firstly, because RLT has such a wide beamwidth, there can be, "significant variations of…dosimetry parameters [such as] wavelength, irradiance or power density, pulse structure, coherence, polarization, energy, fluence, irradiation time, contact vs non-contact application, and repetition regimen" (Avici, et al., 2013). As a result of the infinite variations, there is a high probability of patients receiving burns (Avici, et al., 2013). Notably, Avici et al. (2013) view this form of phototherapy with criticism, a lens that is respected across the scientific field in order for a reliable application like RLT to be distributed across the world. Access to this type of treatment is also an additional concern of RLT. Despite the numerous pieces of evidence that display the success of RLT, this form of phototherapy has yet to be implemented into the mainstream of medicine which, "makes it unavailable to patients who could benefit from it." (Sontea et al., 2013). Many studies have been conducted without, a "proper understanding of biological effects of light…[and] scientific methodology" (Sontea et al., 2013) due to the novel nature of RLT. In short, the recent development of LED arrays is surrounded by an insatiable understanding of the true effects of RLT and the lack of time for conducting thoroughly planned experiments. Many scientists have inquired if the combination of blue and red light would significantly improve patient recovery, for instance. For example, Avici et al. (2013) discuss the recent usage of phototherapy for acne treatment and their paper states that "mainly blue light, red light or combination of both" can be used, emphasizing the uncertainty around the appropriate wavelength to be used for specific treatments, such as acne. As light

consists of a wide range of frequencies, often ranging from 400 to 700 nanometers, further research is critical to solidify the appropriate range where humans can use RLT safely.

That being said, scientists argue that the advantages of RLT overpower the risks. Nutrisense, a certified program that analyzes wellness states that "[l]ight therapies like RLT work by causing a controlled impact on your skin to promote tissue repair, rejuvenate your cells, and stimulate regeneration. Because this sort of light therapy doesn't penetrate the skin more than five millimeters, it's believed not to cause any long-term damage" (2022). This form of therapy has been used by people all across the world to help with rejuvenation and tissue repair, displaying a promising solution for the future of skin health.

5. Conclusion

Red light therapy is a recent scientific development that uses LED arrays to help with many recovery processes. This form of phototherapy can be used, "to treat a multitude of conditions that require stimulation of healing, relief of pain and inflammation, and restoration of function," (Avici et al., 2013). These solutions are possible due to an internal cell relationship where the absorption of light initiates a signaling cascade which allows the body to react in a certain way. To list a few, the photons help enhance enzyme activity, mitochondrial respiration, and ATP production (Avici et al., 2013). As all of these cellular responses are triggered by infrared light, phototherapy "effectively promotes wound healing" (Sontea, et al., 2013). In addition to these benefits, RLT provides a safe, variable, and cost-efficient solution for anyone to improve skin complexity, reduce inflammation, and stimulate overall healing. On the contrary, recent developments in LED arrays have risks as well. Firstly, the unknown nature of how phototherapy affects our bodies creates uncertainty and controversy around the proper use of RLT. When distinct answers are not provided, scientists are hesitant to claim that RLT is successful, which in turn projects wariness to patients who are curious to use RLT. Secondly, the wide variety of light parameters can create probable burns on patients as a particular setting on one person may not work on another. Lastly, access to RLT is an issue because of the unconventional belief surrounding this form of phototherapy. Without proper research, patients are unable to access RLT in a consistent manner. Subsequently, future researchers should consider testing the effects of RLT and its different parameters with willing volunteers to test the effectiveness of this novel solution. Experimenting with different wavelengths, minutes per session, and an overall number of sessions will help catalyze and confirm the science behind RLT. Furthermore, researchers should consider using RLT for high-performing athletes to observe how effective this form of light therapy is in energy reproduction, which would be easily seen in athletes. In conclusion, the recent development of RLT result in thorough scientific conversations, where pros and cons are battled out in hopes to build technology that advances humanity.

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